

**South Carolina  
Department of Health and Environmental Control**

**Total Maximum Daily Load Development for  
Fecal Coliform Bacteria  
Lower Saluda River and Tributaries**

**Stations:**

**Lower Saluda S-149, Twelve Mile Creek S-294, Kinley Creek S-260  
(HUC 03050109-210)**

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Bureau of Water**

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**South Carolina Department of Health  
and Environmental Control**

## Executive Summary

Lower Saluda River and the tributaries Kinley Creek and Twelve Mile Creek (at Stations S-149, S-260 and S-294 respectively.) were placed on the South Carolina's 2000 and 2002 303(d) list of impaired water bodies because of violations of the fecal coliform bacteria water quality standard. Fecal coliform bacteria are an indicator of possible contamination by fecal matter and are thus a public health concern due to the potential for exposure to pathogens through contact recreation. Monitoring stations S-149, S-260 and S-294 failed to attain recreational use support by exceeding the state standard of 400 colonies per 100ml sample. During the assessment period of 1994 through 1998 standards were exceeded in 17% of samples taken at S-149 (N=30), 90% of samples taken at S-260 (N=31) and 21% at S-294 (N=58). The averages of all standards exceedances were 1124, 8650, and 815 colonies/100ml respectively. Maxima at the stations were 2500, 58000, and 3,000. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for all pollutants causing impairment of waters of the State. This TMDL was developed to determine the maximum amount of fecal coliform bacteria that the Lower Saluda River and these tributaries can receive from both point and nonpoint sources and still meet water quality standards. EPA's BASINS model and Watershed Characterization System were used to estimate the continuous in-stream concentration of fecal coliform bacteria. Based on this estimation, the sum of the allowable loads of fecal coliform bacteria pollution from all contributing point and nonpoint sources was calculated. This TMDL takes into consideration seasonal variations. Conservative assumptions regarding pollutant sources in the watershed allow for a margin of safety to ensure that the water body can be used for recreational use purposes consistent with State and Federal water quality goals. The proposed TMDLs represent reductions to the existing loading of 89.2 % overall to the Saluda River above Station S-149, 92.1% to Kinley Creek above S-260 and 89.9 % to Twelve Mile Creek above station S-294. The reductions are directed primarily at runoff from urban and agricultural lands, possible failing septic systems, livestock with uncontrolled access to streams and other unknown sources. Due to limits in source identification information, water quality data, land use, and other data limitations, this TMDL is only an initial estimate. This TMDL will begin the process of a phased implementation of measures that will ultimately result in achievement of fecal coliform bacteria standards in Lower Saluda River watershed. As implementation progresses, and/or more data are obtained, this TMDL may be revised accordingly to facilitate the most efficient remediation of fecal coliform bacterial pollution in the watershed.

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## **Lower Saluda River and Tributaries: Lower Saluda River, Kinley Creek, and Twelvemile Creek, (03050109-210)**

### **1.0 INTRODUCTION:**

#### **1.1 Background**

Levels of fecal coliform bacteria can be elevated in water bodies as the result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA, 1991). This TMDL is targeted at three stations in the Lower Saluda watershed. S-149 is located in the Lower Saluda main stem approximately 3 river miles downstream from the Lake Murray dam. S-294 is located on Twelve Mile Creek which is tributary to the Lower Saluda River. Kinley Creek is monitored at station S-260. These two tributaries meet the Lower Saluda River downstream of station S-149. Another downstream station initially included in this TMDL model (S-298) was removed from the 2002 303(d) list after new data indicated that standards were met at that location. Therefore it was not further considered in this TMDL.

#### **1.2 Watershed Description**

The Lower Saluda River watershed comprises 265 km<sup>2</sup> (102 mi<sup>2</sup>) in Richland and Lexington Counties, South Carolina. The Lower Saluda River is considered to begin at the tail race of the South Carolina Electric and Gas Company's Saluda Hydroelectric Station which impounds the 51,000 acre Lake Murray Reservoir (Figure 1) near Columbia, SC. The Lower Saluda River watershed has several named tributaries two of which are part of this TMDL: Twelve Mile Creek, which drains part of the Town of Lexington and Kinley Creek which drains a largely built out suburban area of the Columbia Metropolitan area. The Lower Saluda River watershed also has several other important tributaries including Rawls Creek for which a TMDL has already been approved.

The Lower Saluda River watershed is in the Piedmont region of South Carolina. Soils in the watershed are generally well drained and consist of an association of Lakeland-Tatum-Georgeville-Applying soils.

Land use in the Lower Saluda River watershed in the area of concern varies widely. The eastern side of the Saluda River nearest the City of Columbia is predominantly urban whereas the western side of the watershed still contains considerable forest and agricultural land use. However extensive urban growth is occurring in the Twelvemile Creek watershed and is expected to continue at a rapid pace. The Kinley Creek watershed is extensively urbanized with 71.2% of the watershed built up. The segment of the

Lower Saluda main stem discussed here receives considerable urban drainage from the eastern side of the watershed primarily via Rawls Creek. Table 1 and Figure 3 provide a breakdown of land use for the entire watershed. Overall forestland still makes up the largest percentage (54.8%). The remaining percentages are cropland (21.6%), urban (19.9%) and pasture land (3.7%) (based on MRLC landsat data 1994).

### **1.3 Water Quality Standard**

The impaired streams tributary to Lower Saluda River are designated as Class Freshwater (FW). Waters of this class are described as follows:

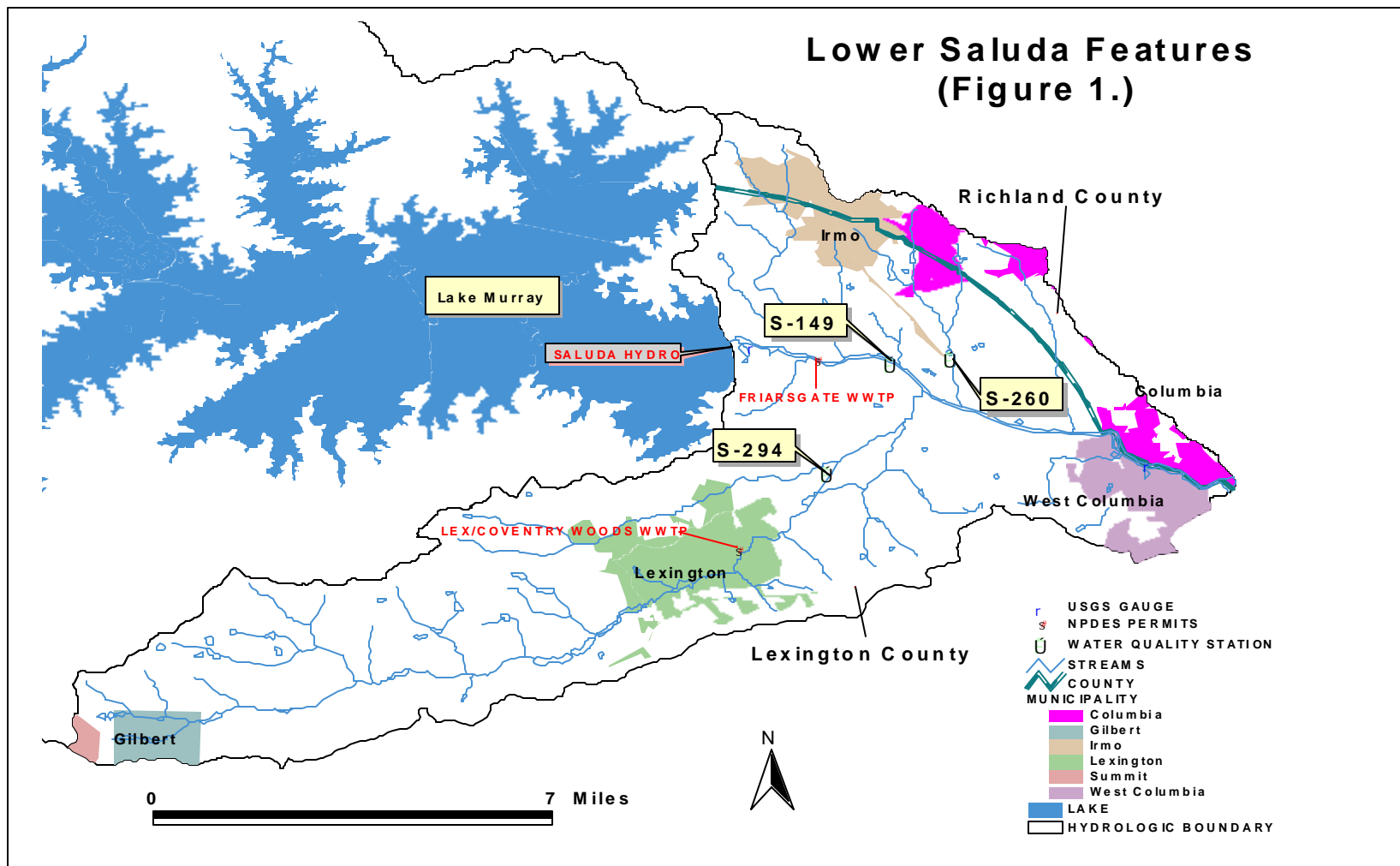
“Freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses.” (R.61-68)

The main stem of the Lower Saluda River is classified as Trout Put Grow and Take (TPGT) due to the cold-water fishery potential of the low temperature flows from the reservoir fore bay releases just upstream.

“Freshwaters suitable for supporting growth of stocked trout populations and a balanced indigenous aquatic community of fauna and flora. Also suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable also for industrial and agricultural uses.

The South Carolina standard for fecal coliform in Freshwater (FW) and (TPGT) is:

“Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30-day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.” (R.61-68).



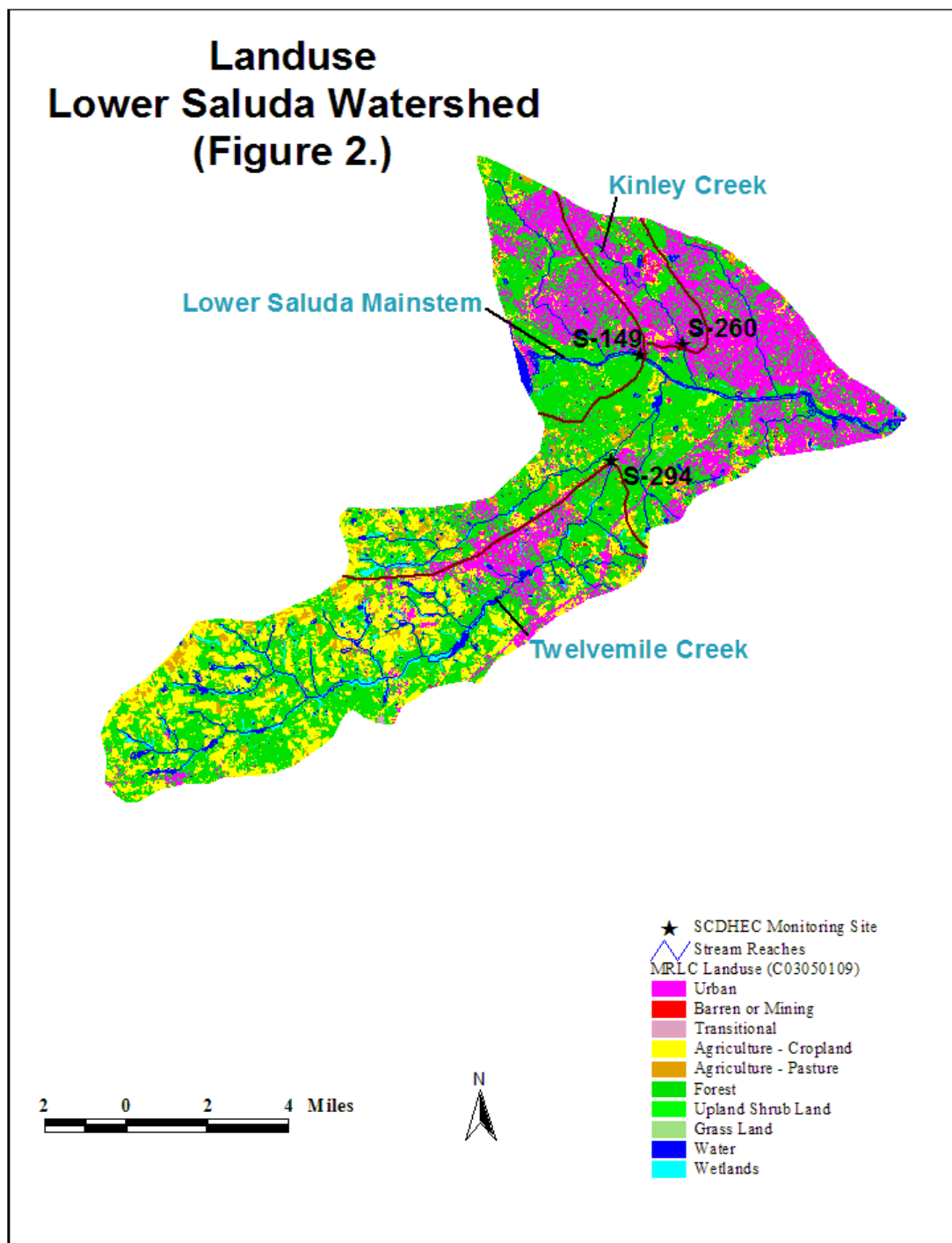


Figure 2. Land use in the Lower Saluda River watershed from National Land Cover Data.

## 2.0 WATER QUALITY ASSESSMENT

A water quality assessment was conducted using data from SC DHEC's ambient water quality monitoring program as detailed in the Watershed Water Quality Assessment: Saluda River Basin published in December 1998. This assessment identified these stream stations as impaired. These water bodies were listed on the 2000 South Carolina 303(d) list. The Lower Saluda River and the tributaries were also included on the 2002 list (Appendix B). Waters in which no more than 10% of the samples collected over a five-year period are greater than 400-cfu/100 ml (cfu, counts, colonies, or # are equivalent units for this TMDL) are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10 percent of samples greater than 400 cfu/100 ml are considered impaired and listed for fecal coliform bacteria on the South Carolina 303(d) List. The impaired water bodies are described in Table 2. Table 2 also gives the percentages of samples that exceeded the standard during the assessment period (1994- 1998) and the mean value of these excursions for this period. A subsequent assessment (1996-2000) indicates that impairment is continuing at a similar magnitude. Analysis of a larger data set indicates that impairment is associated mainly with significant antecedent precipitation in Twelve Mile Creek. Kinley Creek seems to have significant impairment in both wet and dry periods. When considering the larger data set (92-98) seventy percent of impairments in Twelve Mile Creek (S-294) occurred after significant antecedent rainfall ( $\geq 0.5$  inch/48hrs). Forty percent of the excursions in the Lower Saluda (S-149) segment occurred after significant rainfall. Due to the influence of large, relatively low bacteria concentration flows from the dam it appears that impairment at S-149 is complex and cannot be attributable to wet weather periods alone. Kinley Creek however frequently reaches excursion levels in both wet and dry weather periods. Thirty one percent of the excursion periods occurred in wet weather while dry weather was associated with the remainder of excursions. Since S-149 and S-260 are sampled only in summer months it is not possible to assess seasonal effects in the existing data. S-294 is sampled year round. In Twelvemile Creek, seventy eight percent of standards excursions occurred during warm weather months (May-October).

## 3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria enter surface waters from both point and nonpoint sources. Poorly treated municipal sewage has been a major source of fecal coliform in the past; however, with improved treatment and enforcement municipal wastewater discharges are not usually the primary reason for chronic fecal coliform impairments. All point sources must have a NPDES permit. In South Carolina NPDES permittees that discharge sanitary wastewater must meet the state standard (200 geometric mean and 400 maximum cfu/100ml) for fecal coliform at the point of discharge.

Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some

sources are related to land use activities that accumulate fecal coliform on the land surface, which then run off during storm events. Other sources are more or less continuous. Potential nonpoint sources of fecal coliform bacteria include animal defecation, manure application, illicit storm drain connections, failing septic systems, and leaking sanitary sewers.

### **3.1 Point Sources**

There are two active point sources in the Lower Saluda River watershed that discharge fecal coliform above the water quality stations in question (Table 3). The largest discharger is the Lexington/Coventry Woods facility located above station S-294 on Twelvemile Creek. This facility has a permitted discharge of 1.95 million gallons per day (MGD), however actual discharge monitoring reports for the period indicated an average discharge of 1.05 MGD during the 1994-98 period. The average load for this period was  $7.44 \times 10^8$  cfu/day. The discharger with the second largest load is located on the Lower Saluda River above S-149. The Friarsgate WWTP has a permitted flow limit of 1.2 MGD with an average observed flow of 0.69 MGD based on DMR data. The fecal coliform load from this discharger averaged  $5.6 \times 10^8$  cfu/day for 1994-98. For allocation runs of the model and determination of the TMDL, the permitted flow and fecal coliform limit of 200 cfu/100ml monthly average were used to calculate the waste load. These dischargers contribute  $4.43 \times 10^{11}$  per 30 days at S-294, and  $3.03 \times 10^{11}$  per 30 days at S-149 towards the TMDL. Based on the DMR data these NPDES permitted dischargers are not considered to be significant contributors to use support violations in the watershed. However there were a number of unsatisfactory permit compliance sampling inspections conducted by DHEC EQC District personnel at Lexington/Coventry Woods facility that exceeded effluent limits for fecal coliform during the period of interest. These could not be linked directly to surface water exceedances but these occurrences indicate that compliance/enforcement efforts should remain at a high level. Although not considered as a waste load, the effluent from the dam was modeled as a point source since those flows had a dominant impact on water quality at S-149. A background FC rate of  $1.02 \times 10^{10}$  cfu/hour was required in order to approximate the observed water quality conditions.

There are six municipalities in the watershed that have or will have NPDES MS4 (Municipal Separate Storm Sewer System) permits. These permitted sewer systems will be treated as point sources in the TMDL calculations below. However for modeling purposes all urban areas will be evaluated together as urban nonpoint sources.

### **3.2 Nonpoint Sources**

#### **3.2.A. Wildlife**

Wildlife (mammals and birds) contribute a low level of fecal coliform to surface waters. Wildlife wastes are carried into nearby streams by runoff during rainfall. Deer are used as a surrogate for all wildlife. The SC Department of Natural Resources (Charles Ruth, DNR Deer Project Supervisor, personal

communication, 2001) has estimated a density of 5-10 deer/mi<sup>2</sup> for this area. Deer habitat includes forest, cropland, and pasture land. Deer are assumed to be distributed evenly throughout their habitat and the population uniform during the modeling period. Wildlife are, in most situations, the only contributors of fecal coliform bacteria to forestland which usually has the lowest loading rates per unit of area of any land uses. Other wildlife, represented as additional deer in the model, contribute to forest, crop, and pasturelands as well. Loading of fecal coliform bacteria from wildlife is considered background. Due to the relatively urbanized nature of this watershed, deer populations in the area are much lower than state averages. However other animals contribute to wildlife loads such as possum, squirrel, muskrats and birds. Estimates of furbearing populations were obtained from SC DNR and a wildlife contribution equivalent of 15 deer/sq mile was used in this TMDL as background. The distribution of wildlife-derived bacteria is calculated at  $1.17 \times 10^7$  bacteria/acre/day throughout the three sub-watersheds.

Table 1. Land use distributions in the Lower Saluda River watershed by sub-watersheds (acres).

Sub-watershed	Lower	Kinley	12 Mile	Totals
	Saluda	Creek	Creek	
Land Use Class				
<b>Built-up</b>	3002.9	2146.4	3282.9	8432.2
	31.0%	71.2%	11.1%	19.9%
<b>Forest</b>	5877.0	685.8	16554.5	23117.3
	60.6%	22.7%	55.8%	54.8%
<b>Pasture</b>	235.2	8.7	1342.8	1586.7
	2.4%	.3%	4.5%	3.7%
<b>Row Crops</b>	547.0	173.05	8462.0	9182.0
	6.0%	5.7%	28.6%	21.6%
<b>Totals</b>	9662.9	3013.9	29642.2	42318.2

Table 2. Sampling station descriptions and statistics of fecal coliform bacteria samples during the 1994-98 assessment period.

Station Description	Stations	% Violations	Mean Fecal Coliform Conc. (cfu/100ml)	Number of Samples
Lower Saluda River at Mepco Electric plant	S-149	17	259	30

Water intake				
Kinley Creek at St. Andrews Road in Irmo	S-260	90	8650	31
Twelve Mile Creek at US 378	S-294	21	308	58

### 3.2.B Untreated Wastewater Inputs

Using the Watershed Characterization System, GIS coverages were linked to produce an inventory of the number of septic systems in use in the sub watersheds based on unsewered population estimates from the 1990 census. Based on Horsley and Witten (1996) the average waste flow per person was assumed to be 70 gal/capita/day. The average household consisted of 2.63 persons. Septic systems were assumed to have a failure rate of 10 % (Schueler, 1999). Other initial assumptions were that all wastewater reached the stream and the concentration of fecal coliform in that wastewater was  $10^4$  cfu/100ml (Horsley and Witten, 1996). This source contributes  $2.08 \times 10^{11}$  cfu/day to the Lower Saluda River and its headwaters below the dam. In the Kinley Creek sub-watershed  $4.08 \times 10^{10}$  cfu/day was estimated and in the more rural Twelve Mile Creek watershed loading was estimated to be  $4.03 \times 10^{10}$  cfu/day (Table 5). In the process of model calibration, septic system loading was estimated to be greater per failing septic system in the Lower Saluda and Kinley Creek watersheds than the more rural Twelve Mile Creek. This may be due to the more concentrated and often older developments in these areas.

Sanitary sewerline leakage and overflows are a common source of contamination in the urban environment. Initial loadings of these sources were estimated at 1% of the permitted flow from the permitted discharges in the watershed. Initial concentrations were 20,000 cfu/100ml (Schueler, T.R., 1999).

### 3.2.C Urban Storm Runoff

In addition to more or less continuous sources of fecal coliform bacteria loading in urban watersheds, there is generalized accumulation of FC upon the urban land surface available for runoff during rain events. Sources of fecal coliform bacteria in urban areas include pets, particularly dogs. Much of the increase in loading from these areas is due simply to the increase in connected impervious surfaces and the resulting highly efficient mechanism for conveying available pollutants. The accumulation rate of fecal coliform bacteria for the built-up land was initially based on literature values (Horner, 1994). After calibration the fecal coliform build up rate was estimated to be in a range of  $1.41 \times 10^9$  to  $2.18 \times 10^9$  cfu/acre/day for the individual sub-watersheds. Some variation in this build up rate was expected due to differences in age and density of the urbanized portions of the watersheds.

Table 3. Existing point source discharges in the Lower Saluda River watershed area of interest.

Discharger Name	NPDES Number	Receiving Stream	Flow (mgd)	Load (cfu/30 day)	Comments
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Lexington/Coventry Woods	SC0026735	Twelve Mile Creek	1.05	$2.23 \times 10^{10}$	Active
Friarsgate/Rawls Creek	SC0036137	Lower Saluda River	0.69	$1.67 \times 10^{10}$	Active

### 3.2.D. Agricultural Activities

Agricultural land can be a source of fecal coliform bacteria loading. Runoff from pastures, confined animal operations, the improper land application of animal wastes, and animals with access to creeks can all contribute to the load of fecal coliform. A table of fecal coliform bacteria production rates for livestock and other animals is presented in Appendix E. Agricultural Best Management Practices or BMPs such as buffer strips, alternative watering sources, limiting livestock access to creeks, and the proper land application of animal wastes can reduce fecal coliform loading to water bodies.

#### Pasture

Agricultural land use is still extensive in the Twelve Mile Creek watershed although pressure to suburbanize is high. Runoff from pastures where livestock graze can be a significant source of fecal coliform loading. Additionally litter and manure are occasionally applied to pasture land to promote the growth of forage. Over 1,343 acres of pastureland exist in that watershed, much of which still retains use for some livestock grazing. After calibration, the input accumulation load for pasturelands was estimated to be  $1.18 \times 10^{10}$  cfu/acre/day. This accumulation rate was calculated using EPA's Watershed Characterization system using agricultural census data derived from the 1999 South Carolina Agricultural census for Lexington County. Pastureland rates were derived using Lexington county livestock rates per acre of pastureland in the county. Livestock estimated included cattle, chickens, horses, and swine.

The Lower Saluda main stem and Kinley Creek receive drainage from 229 and 9 acres of pastureland respectively. With some exceptions, pastureland in these more urbanized areas is not used extensively for grazing or land application.

Livestock can also contribute to fecal coliform loading through direct discharge to the stream. Cattle frequently find their drinking water in stream channels and will loaf there when given the opportunity. This practice makes possible direct defecation into the water body by the livestock. Loading from this source is estimated from the number of non-dairy cattle and the percentage of time they might spend in streams. Assumptions for these calculations are that beef cattle are not confined, have access to streams, and they spend 0.025 % of the time in the streams (EPA Region 4 personal communication, 2001). The loading was estimated to be  $2.27 \times 10^{10}$  cfu/day for Twelve Mile Creek. This load represents roughly the effect of having one beef cow's waste discharging somewhere to the creek for about 4.8 hours per day. Of course, in reality this effect would most likely be much more random with increases in load when

numerous livestock are together in the stream and zero loading when none are in the stream. However, for the purposes of this TMDL estimated loading from the cattle-in-streams was treated as continuous sources for input into the model (Table 4). Only Twelve Mile Creek had a livestock population large enough to consider direct discharge as a likely source of loading. The total number of cattle estimated to reside in the Twelvemile Creek watershed was 879 (S.C. Agricultural Statistics Service, 1999).

## Croplands

There are 8,462 acres of cropland in the Twelvemile Creek watershed with 173 and 546 acres in Kinley Creek and the Lower Saluda main stem respectively. Lexington County has an extensive poultry and chicken raising and processing industry. While much of this activity occurs outside of the watershed, agricultural census estimates indicate that up to 3,563,000 chickens were raised and sold per year in the nine permitted poultry facilities in the Twelvemile Creek Watershed. Litter from these operations is applied primarily to pasture land; but also to cropland in the Twelvemile Creek watershed. Operators are required to follow their poultry waste management plans for the application of litter and manure. All of these animal operations have ND (no discharge) permits. The fecal coliform spreadsheet tool of WCS was used to calculate the amount of fecal coliform deposited on croplands. The buildup rate of fecal coliform bacteria from pasture runoff was estimated to be a maximum of  $1.44 \times 10^8$  cfu/acre/day occurring mainly in the spring and summer months when application typically occurs. Build up rates for cropland are considerably less than for pastureland due to surface characteristics of cultivated soil and the ability to disk in litter making it less available to runoff.

Table 4. Livestock-in-streams loading rates for fecal coliform and flow for model input.

Sub-watershed Name	Sub-watershed number	Total # Cattle	Fecal Coliform Loading Rate (cfu/day)	Flow Rate (cfs)
Twelve Mile Creek	009	879	2.26E+10	1.88E-06

Table 5. Fecal coliform loading and flow from septic systems by sub-watershed.

Sub-watershed Name	Sub-watershed number	Failing Systems	Fecal Coliform loading (cfu/day)	Flow (cfs)
Lower Saluda River	010,011,012	149	2.08E+11	4.1E-02
Kinley Creek	005	60	4.08E+10	1.7E-02
Twelve Mile Creek	009	400	4.03E+10	2.5E-02

## **4.0 MODELING**

Watersheds with varied land uses and numerous potential sources of pollutants typically require a complex model to ascertain the affect of source loadings on in-stream water quality. Although watershed specific data is typically insufficient for a high degree of certainty, this relationship must be understood to some degree in order to develop an effective TMDL. In this section, the numerical modeling techniques that have been developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed as applied to the Lower Saluda River watershed.

### **4.1 Model Selection**

The Lower Saluda River watershed is a relatively large basin with significant land uses with the potential to cause impairment of water quality. The US EPA has assembled a variety of tools to use in the development of TMDLs. The GIS based dynamic modeling tool - Watershed Characterization System or WCS (USEPA - Region 4, 2001), was used. WCS, which is a version of BASINS (US EPA, 1998), has additional source loading calculation tools, updated data, and is focused on several specific southeastern states including South Carolina. WCS includes a geographic information system (GIS) interface. This tool was used to display and analyze GIS information including land use, point source discharges, soil types, population, and stream characteristics. The WCS was used as an aid to identify and summarize the sources of fecal coliform bacteria in the watershed, as well the other factors that affect its fate and transport.

Information collected using WCS was used in a series of spreadsheet applications designed to compute fecal coliform bacteria loading rates in the watershed from varying land uses including urban, agricultural, and forestry. These spreadsheets are adaptable to local conditions and various factors can be included to incorporate regional or watershed differences such as manure application practices, local septic tank failure rates or more accurate population data.

Flow simulation and computed loading rates were used in a hydrologic and water quality model, NPSM (Non-Point Source Model), that is built around the Hydrologic Simulation Program Fortran or HSPF. These tools can be used to test simulations of the deposition and transport of fecal coliform bacteria, and the resulting water quality responses. NPSM simulates nonpoint source runoff as well as the transport and flow of pollutants in stream reaches. A necessary feature of NPSM is its ability to integrate both point and nonpoint sources of fecal coliform bacteria and to determine the in-stream water quality response.

### **4.2 Model Set Up**

The Lower Saluda River watershed was delineated into twelve sub-watersheds in order to characterize the relative fecal coliform bacteria contributions from the significant contributing sub-watersheds. Initially

the model was set up with S-298 at the bottom of the watershed as the terminal point of the model. However during the TMDL development process, this station was de-listed due to more current data showing that the station met standards for fecal coliform. The remaining three stations were modeled separately. Twelvemile Creek was modeled using only watershed 009, Kinley Creek using 005 and Lower Saluda Main stem using watersheds 010, 011 and 012 combined (see Figure 2). Watershed delineation was based on the RF1 stream coverage and elevation data. A continuous simulation period from October 1, 1988 to September 30, 1998, was used in the analysis to provide sufficient time to assess the watershed dynamics over a variety of meteorological conditions. The period from October 1, 1988 to December 31, 1989, was not considered since the model can initially be unstable. The period from January 1, 1990 to September 30, 1998, was used to identify the critical condition period from which to develop the TMDL.

An important factor driving model results is the precipitation data contained in the meteorological file used in the simulations. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Columbia Metro Airport meteorological station were used in the simulations.

#### **4.3 Model Calibration**

The calibration of the watershed model is a two-step process; first hydrology and then water quality. The simulated stream output is compared to the graphed actual data as obtained by the U.S. Geological Survey (USGS) stream gauging station or actual water quality data obtained at the SCDHEC monitoring stations.

Flow calibration was achieved by adjusting model parameters in HSPF modules. Parameters such as evapotranspiration rates, infiltration, upper and lower zone storage, groundwater storage and recession, and interflow discharge rates control the movement and storage of water in the watershed. These parameters were adjusted until the simulated hydrology was in reasonable agreement with the actual flow data over several years. The Lower Saluda River has a longstanding gauge downstream from the Lake Murray dam (02169000) approximately 5.5 miles below station S-149. Neither Kinley Creek nor Twelvemile Creek have flow gauging stations. Additionally flow is monitored about 0.5 miles below the dam outfall at (02168504) Hydrology parameter values used for the Lower Saluda model calibration were used for all three watersheds. Hydrology was calibrated to observed data at the USGS 02169000 station. Hydrology calibration summary and plots are shown in Appendix C.

Water quality calibration results are shown in Appendix D. Results show that the model adequately simulates the general fecal coliform bacteria concentration profiles for the three water quality stations. Water quality data was limited and perfect correlation was not achieved especially during wet weather periods. Base line conditions were modeled somewhat better than rain events. This may be due to local

variation in precipitation relative to the Columbia Metro Weather station which was located 10.8, 6.6, and 7.2 miles from the stations: S-149, S-294 and S-260 respectively. Appendix D contains graphs of five years of water quality calibration results along with a log plot for each station. Water quality calibration for these watersheds was particularly difficult at the main stem Lower Saluda due to the fact that a large hydro project supplies flows to S-149 which can confound the normal rainfall runoff effects on water quality. The final water quality calibration model produced the existing fecal coliform loads found in Table 6.

Table 6. Existing Lower Saluda fecal coliform loading

<b>Existing Fecal Coliform Load</b>					
Impaired Stations	Loading from Permitted Facilities (Counts/30days)	Loading From Land Runoff (counts/30 days)	Loading from Cattle in Stream (Counts/30 days)	Direct Loading From Nonpoint Sources (Counts/30 days)	Total Existing Load (Counts/30days)
S-149	$1.67 \times 10^{10}$	$4.03 \times 10^{13}$	N/A	$8.09 \times 10^{13}$	$1.21 \times 10^{14}$
S-260	N/A	$5.95 \times 10^{13}$	N/A	$2.32 \times 10^{12}$	$6.18 \times 10^{13}$
S-294	$2.23 \times 10^{10}$	$5.53 \times 10^{13}$	$6.8 \times 10^{11}$	$1.55 \times 10^{12}$	$5.75 \times 10^{13}$

#### 4.4 Critical Conditions

EPA regulations at 40 CFR 130.7(c)(1) require that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that established uses of the stream (in this case primary contact recreation) are protected. For this TMDL the 30-day period for which the model predicts the largest violation of the geometric mean standard (200cfu/100ml) represents the critical condition. Basing the TMDL on this period ensures that the standard can be met throughout the period of simulation. For Twelve Mile Creek (S-294) the critical condition was a relatively dry summer time period and for Kinley Creek (S-260) it was a summer period with moderate rainfall amounts. For the Lower Saluda main stem (S-149) the critical condition occurs during a mostly dry winter period in which flows from the Saluda Hydro station were also low (15<sup>th</sup> percentile). The critical 30 day periods for this model are as follows:

- **S-149 Lower Saluda Main stem**      **11/2/1996-12/1/1996**
- **S-260 Kinley Creek**                      **6/6/1994 – 7/5/1994**
- **S-294 Twelve Mile Creek**              **7/18/1993- 8/16/1993**

In addition to basing decisions on achieving the 30-day geometric mean standard during the critical period; the percentages of predicted daily values exceeding the 400 cfu/100 ml standard were also calculated (Appendix G).

## 4.5 Model Uncertainty

There are several sources of uncertainty in the Lower Saluda River model. These include rainfall data collected from outside of the watershed, limited water quality data, inherent variability in fecal coliform sampling, and lack of availability of observed data on sources such as failing septic systems, illicit discharges, and sanitary sewer overflows. These uncertainties should be considered in evaluating the recommendations in this TMDL.

## 5.0 TMDL

### 5.1 TMDL Concept

A total maximum daily load (TMDL) for a given pollutant and water body is comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), implicitly and/or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide the basis on which to target water quality-based controls.

40 CFR 130.2 (i) states that TMDL's can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure. TMDL's for the impaired water bodies here are expressed in terms of a percent reduction, and where possible, as counts per 30 days. The TMDL value represents the maximum daily load the stream can transport over a 30-day period and maintain the water quality criterion.

### 5.2 Margin of Safety

There are two basic methods for incorporating the margin of safety or MOS (USEPA 1991):

1) *implicitly* incorporate the MOS using conservative model assumptions to develop allocations, or 2) *explicitly* specify a portion of the total TMDL as the MOS and use the remainder for allocations. For this TMDL the MOS is explicit through the use of a target 5% below the actual standard (190cfu/100 ml geo-mean, 380cfu/100ml instantaneous). Further safety is added by using a multi-year simulation period and by making other conservative assumptions in developing the model. In allocation of the point sources, discharge was assumed to be the maximum permitted limit. Other conservative assumptions are that all failing septic systems discharge directly into streams, and that all impervious land is directly

connected to the stream network.

### 5.3 Wasteload Allocations

As mentioned earlier, there are currently two active wastewater dischargers with permits to discharge fecal coliform to the water body segments of interest. Because the permit limits for fecal coliform for these facilities are already at the water quality standard, no reductions are required from these facilities.

Table 7. TMDL Wasteload Allocations (WLA) for Lower Saluda River.

Discharger Name	NPDES Number	Receiving Stream	Permitted Flow (mgd)	Permitted Concentration	Load (cfu/30 days)
Lexington/Coventry Woods	SC0026735	Twelve Mile Creek	1.95	200 cfu/100ml	$4.43 \times 10^{11}$
Friarsgate/Rawls Creek	SC0036137	Lower Saluda River	1.20	200 cfu/100ml	$2.73 \times 10^{11}$

### 5.4 Load Allocation

Nonpoint sources were arranged into three main groups for the model. Sources that accumulate on the land and are then washed into water bodies are under “Loading from land runoff” in Table 8. Direct livestock inputs are considered as an individual category as well. Leaking septic tanks and all other potential sources are considered in the “Direct inputs from nonpoint sources” category. These other sources may include overflowing sewer systems, illegal discharges, and other unknown sources. These unspecified source may reach surface waters without direct association with rainfall and were modeled as a continuous source of fecal coliform.

The loading presented in Table 8 represents one scenario where reductions were applied sequentially to loading from runoff (agricultural and urban), livestock and other direct inputs loading. Reductions are applied differently to different sub-watersheds because the model had varying sensitivity to given source adjustments among the sub-watersheds. Other reduction scenarios are possible so long as the water quality standard can be met at the compliance points.

Table 8. TMDL Lower Saluda Load Allocations (LA) (cfu/30 days).

TMDL Fecal Coliform Load Allocation				
Impaired Stations	Total LA (Counts/30days)	Loading From Land Runoff (counts/30 days)	Loading from Cattle in Stream (Counts/30 days)	Direct Loading From Nonpoint Sources (Counts/30 days)
S-149	$1.31 \times 10^{13}$	$4.08 \times 10^{12}$	N/A	$9.03 \times 10^{12}$
S-260	$4.91 \times 10^{12}$	$4.80 \times 10^{12}$	N/A	$1.16 \times 10^{11}$
S-294	$5.79 \times 10^{12}$	$5.67 \times 10^{12}$ 15	$3.39 \times 10^{10}$	$9.44 \times 10^{10}$

Plots of 30-day geometric mean existing and predicted TMDL fecal coliform bacteria are presented in Appendix F. The model also predicts that the instantaneous criteria of 400 cfu is not exceeded more than 10% over the period 1993-1998 (Appendix G).

## 5.5 Total Maximum Daily Loads

Total maximum daily loads for fecal coliform for the three stream reaches are given in (Table 9). The TMDLs represent 89.2% – 92.1% reductions from the existing fecal coliform loads. The greatest reduction in loading from nonpoint sources is required in the Kinley Creek sub-watershed.

Table 9. Lower Saluda TMDL

<b>TMDL Components for the Twelve Mile Creek Watershed</b>						
Impaired Stations	WLA (Counts/30days)	MS4 WLA % Reduction	LA (Counts/30day or % reduction)	MOS	TMDL Counts/day or % Reduction	Percent Reduction Required
S-149	$2.73 \times 10^{11}$	89.2	$1.31 \times 10^{13}$	5% LA+Implicit	$1.33 \times 10^{13}$	89.2
S-260	N/A	92.1	$4.91 \times 10^{12}$	5% LA+Implicit	$4.91 \times 10^{12}$	92.1
S-294	$4.43 \times 10^{11}$	89.9	$5.79 \times 10^{12}$	5% LA+Implicit	$6.20 \times 10^{12}$	89.9

A reduction of 89.2 % of fecal coliform loading is recommended for the Lower Saluda River in the watershed above S-149; 92.1% for the Kinley Creek watershed (above S-260); and 89.9% for the Twelve Mile Creek watershed.

There are five municipalities in the watershed that have or will have NPDES permits. Richland County became covered under NPDES Phase I in April of 2000. The City of Columbia ,The Town of Lexington, Lexington County, and the Town of Irmo will eventually be covered under one or more NPDES stormwater permits. The reduction percentages in this TMDL apply also to the fecal coliform waste load attributable to those areas of the watershed which are covered or will be covered under NPDES MS4 (Municipal Separate Storm Sewer System) permits. Compliance by these municipalities with the terms of their individual MS4 permits will fulfill any obligations they have towards implementing this TMDL.

## 5.6 Seasonal Variability

The model simulation covered a multi-year continual period so that all seasons were included. The simulation period included both wet and dry periods. Additionally certain build up rates, cropland manure

application for example, are seasonal and were input as monthly rates in the model simulation.

## 6.0 IMPLEMENTATION

South Carolina has several tools available to reduce loading of fecal coliform bacteria due to agricultural activities as discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina*. Specifically, SCDHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. In addition, SCDHEC will work with the existing agencies in the area to provide nonpoint source education in the Lower Saluda River watershed. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS) and the South Carolina Department of Natural Resources. The Lower Saluda River is a designated State Scenic River and as such has an ongoing advocacy council for Lower Saluda water quality issues. This advisory council has already been active in implementing educational NPS control measures in the Rawls Creek subwatershed above station S-149.

Clemson Extension Service offers a 'Farm-A-Syst' package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. Fencing cattle out of streams and restoring an adequate stream buffer have been shown to reduce pollution entering streams. NRCS can sometimes provide cost share money to land owners installing BMPs. These tools and services can be brought to bear in the implementation of this TMDL.

In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Lower Saluda River.

SCDHEC will work with existing agencies in the region to provide nonpoint source education in the Lower Saluda River watershed to reduce pollution from built-up areas. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Richland and Lexington County Soil and Water Conservation Districts, and the South Carolina Department of Natural Resources. In addition, Clemson Extension has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks.

SCDHEC employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information. In built-up areas, failing septic systems should be repaired or replaced. Also, maintenance of sanitary sewers and prevention of sewer overflows (from blockages) should be emphasized.

SCDHEC is empowered under the State Pollution Control Act to perform investigations of and pursue

enforcement for activities and conditions, which threaten the quality of waters of the state. Enforcement of all existing laws, regulations, and permits applicable within the Lower Saluda watershed will serve to reduce fecal coliform loading when illegal activities contribute to standards contraventions.

The iterative BMP approach defined in the general MS4 storm water NPDES permits is expected to provide significant implementation of this TMDL. Discovery and removal of illicit storm drain cross connections is one important element of the storm water NPDES permit. Public NPS education is another.

Using existing authorities and mechanisms, these measures will be implemented in the Lower Saluda River watershed in order to bring about a reduction in fecal coliform bacteria loading to the Lower Saluda River. The reductions will be targeted at both urban and livestock sources.

DHEC will continue to monitor, according to the basin water quality monitoring schedule, the effectiveness of implementation measures and evaluate stream water quality as the implementation activity progresses. This TMDL may be revised if additional monitoring data and better modeling tools become available.

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<b>94-98</b>	<b>S-294</b>	<b>12 Mile Creek</b>					
01/06/94	110.00						
01/13/94	67.00						
02/02/94	89.00		N=		58.00	# Excursions	12
03/31/94	87.00		Ave		308.14		
04/15/94	500.00		Max		3000.00		
05/17/94	190.00		Ave Excursion		815.00		
06/24/94	620.00		Geo Mean		191.87		
07/06/94	200.00		% Excursions		20.7		
08/24/94	180.00						
09/13/94	250.00						
10/11/94	220.00						
11/29/94	100.00						
12/15/94	150.00						
01/11/95	120.00						
02/07/95	77.00						
03/07/95	140.00						
04/04/95	160.00						
05/16/95	610.00						
06/13/95	660.00						
07/27/95	1500.00						
08/22/95	370.00						
09/25/95	540.00						
10/17/95	380.00						
11/07/95	390.00						
12/04/95	120.00						
01/17/96	57.00						
02/21/96	97.00						
03/13/96	180.00						
04/09/96	92.00						
05/22/96	310.00						
06/06/96	640.00						
07/30/96	130.00						
08/21/96	410.00						
09/26/96	290.00						
10/08/96	3000.00						
11/19/96	400.00						
12/03/96	200.00						
01/08/97	77.00						
02/04/97	48.00						
03/24/97	8.00						
04/15/97	71.00						

<b>94-98</b>	<b>S-294</b>	<b>12 Mile Creek</b>					
06/11/97	140.00						
07/02/97	170.00						
08/28/97	120.00						
09/24/97	280.00						
10/27/97	400.00						
11/20/97	120.00						
12/03/97	67.00						
01/07/98	450.00						
02/10/98	80.00						
03/24/98	25.00						
04/21/98	170.00						
05/26/98	290.00						
06/30/98	450.00						
07/08/98	340.00						
08/19/98	390.00						
09/09/98	380.00						
10/12/98	160.00						

<b>94-98</b>	<b>S-260</b>	<b>Kinley Creek</b>					
05/17/94	2300.00		N=		31	Excursions	28
06/14/94	3500.00		Average		6866.13		
07/06/94	2800.00		Max		58000		
08/24/94	2000.00		Ave Excursion		8650.42		
09/07/94	3200.00		Geomean		2372.		
10/12/94	8400.00		% Excursions		90.3		
05/16/95	5800.00						
06/13/95	22000.00						
07/27/95	58000.00						
08/01/95	300.00						
08/09/95	36000.00						
09/21/95	2200.00						
10/04/95	14000.00						
05/02/96	850.00						
06/05/96	5800.00						
07/27/96	2800.00						
08/20/96	1400.00						
09/18/96	660.00						
10/08/96	5400.00						
05/13/97	40.00						

<b>94-98</b>	<b>S-260</b>	<b>Kinley Creek</b>					
06/09/97	1000.00						
07/15/97	2700.00						
08/14/97	1000.00						
09/04/97	2300.00						
10/14/97	800.00						
05/12/98	40.00						
06/09/98	1400.00						
07/21/98	16000.00						
08/12/98	2100.00						
09/22/98	7300.00						
10/20/98	760.00						

<b>94-98</b>	<b>S-149</b>	<b>Lower Saluda Main Stem</b>					
05/18/94	32.00		N=		30.00	Excursions	5
06/14/94	130.00		Average =		259.93		
07/06/94	18.00		Max		2500.00		
08/24/94	28.00		Ave. Excursion		1124.00		
09/07/94	29.00		Geomean		78.69		
10/12/94	20.00		%violations		16.60		
05/16/95	300.00						
06/13/95	260.00						
07/27/95	450.00						
08/08/95	70.00						
09/21/95	490.00						
10/04/95	380.00						
05/02/96	1200.00						
06/05/96	50.00						
07/23/96	13.00						
08/20/96	18.00						
09/05/96	26.00						
10/08/96	2500.00						
05/13/97	35.00						
06/10/97	18.00						
07/15/97	11.00						
08/13/97	39.00						
09/04/97	41.00						
10/14/97	27.00						
05/11/98	25.00						

06/09/98	78.00						
07/21/98	980.00						
08/12/98	360.00						
09/22/98	83.00						
10/20/98	87.00						

### 2000 303(d) list Excerpt

RAWLS CREEK AT S-32-107	S-287	03050109210	S/BIO	FW	FC
LORICK BR AT PT UPSTRM OF JCT WITH SALUDA RVR	S-150	03050109210	S	FW	FC
SALUDA RVR AT MEPCO ELECT. PLANT WATER INTAKE SSE IRMO	S-149	03050109210	S	TPGT*	DO
<b>SALUDA RVR AT MEPCO ELECT. PLANT WATER INTAKE SSE IRMO</b>	<b>S-149</b>	<b>03050109210</b>	<b>S</b>	<b>TPGT*</b>	<b>FC</b>
FOURTEEN MILE CK AT SR 28	S-848	03050109210	BIO	FW	BIO
TWELVE MILE CK AT SR 106	S-052	03050109210	BIO	FW	BIO
<b>TWELVEMILE CREEK AT U.S. ROUTE 378</b>	<b>S-294</b>	<b>03050109210</b>	<b>P</b>	<b>FW</b>	<b>FC</b>
TWELVEMILE CREEK AT U.S. ROUTE 378	S-294	03050109210	P	FW	CU
TWELVEMILE CREEK AT U.S. ROUTE 378	S-294	03050109210	P	FW	ZN
<b>KINLEY CK AT S-32-36 (ST. ANDREWS RD) IN IRMO</b>	<b>S-260</b>	<b>03050109210</b>	<b>S/BIO</b>	<b>FW</b>	<b>FC</b>
KINLEY CK AT S-32-36 (ST. ANDREWS RD) IN IRMO	S-260	03050109210	S/BIO	FW	BIO

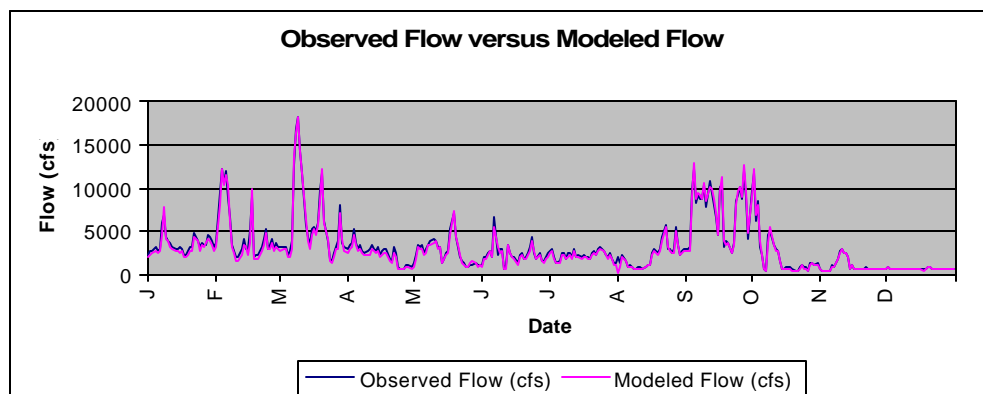
## Lower Saluda Hydrology Calibration

### Annual Hydrology Summary Data: Simulated vs. Observed (cfs)

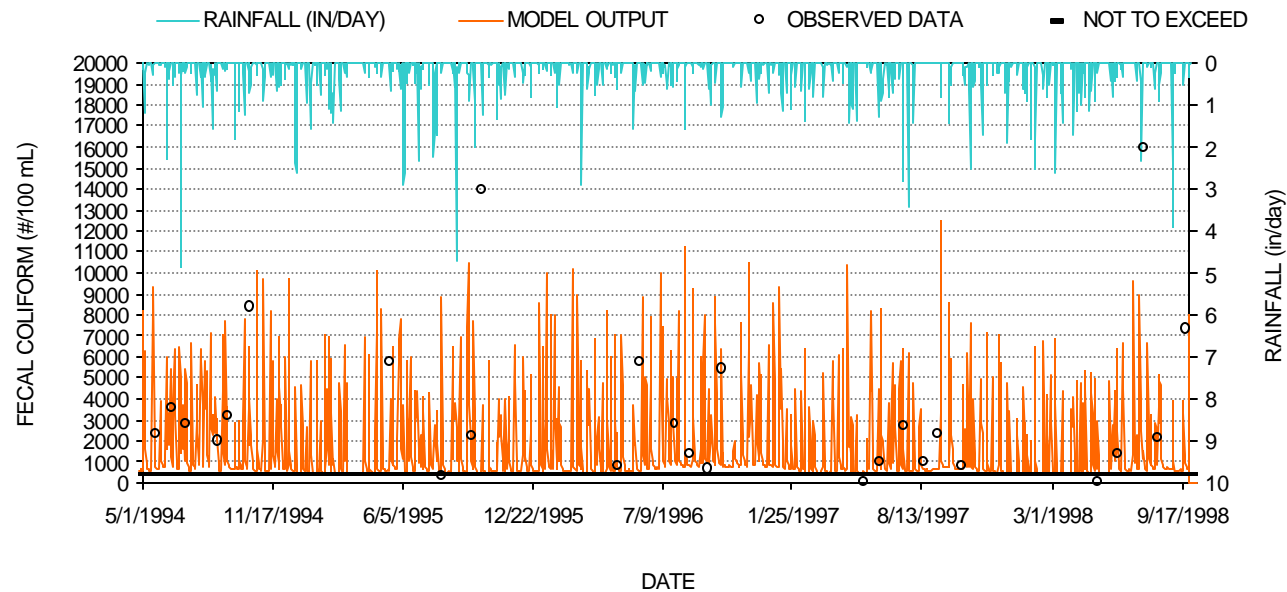
\*1988 should be disregarded due to initial model stabilization period. 1998 had incomplete observed data.

	1/1/1988	1/1/1989	1/1/1990	1/1/1991	1/1/1992	1/1/1993	1/1/1994	1/1/1995	1/1/1996	1/1/1997	1/1/1998	Criteria
Errors (Simulated-Observed)												
Error in total volume:	49	-1	0	-6	4	-3	1	0	-6	-1	-12	10
Error in 50% lowest flows:	32	-2	-1	-14	-9	-4	-7	-6	-12	-3	-84	10
Error in 10% highest flows:	50	-2	3	-3	12	2	5	4	1	0	-2	15
Seasonal volume error - Summer:	81	2	4	-6	4	-5	2	4	-2	4	10	30
Seasonal volume error - Fall:	-6	-1	-1	-8	9	-2	1	-5	-5	-1	#N/A	30
Seasonal volume error - Winter:	39	-15	-1	-5	-3	0	-2	1	-7	-3	-2	30
Seasonal volume error - Spring:	76	3	-7	-7	-3	-9	1	0	-10	-3	-6	30
Error in storm volumes:	61	7	5	9	21	1	13	3	-1	1	-12	20
Error in summer storm volumes:	4	0	-1	0	-2	-29	-3	-14	-7	-14	0	50

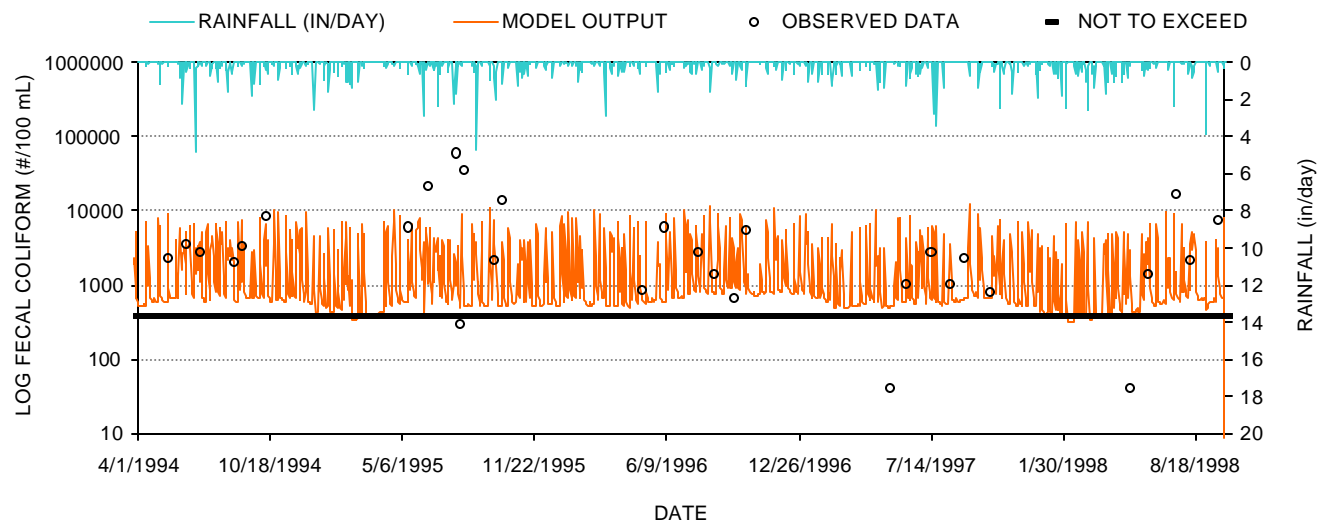
Typical Flow Plot: Observed vs. Simulated: 1996



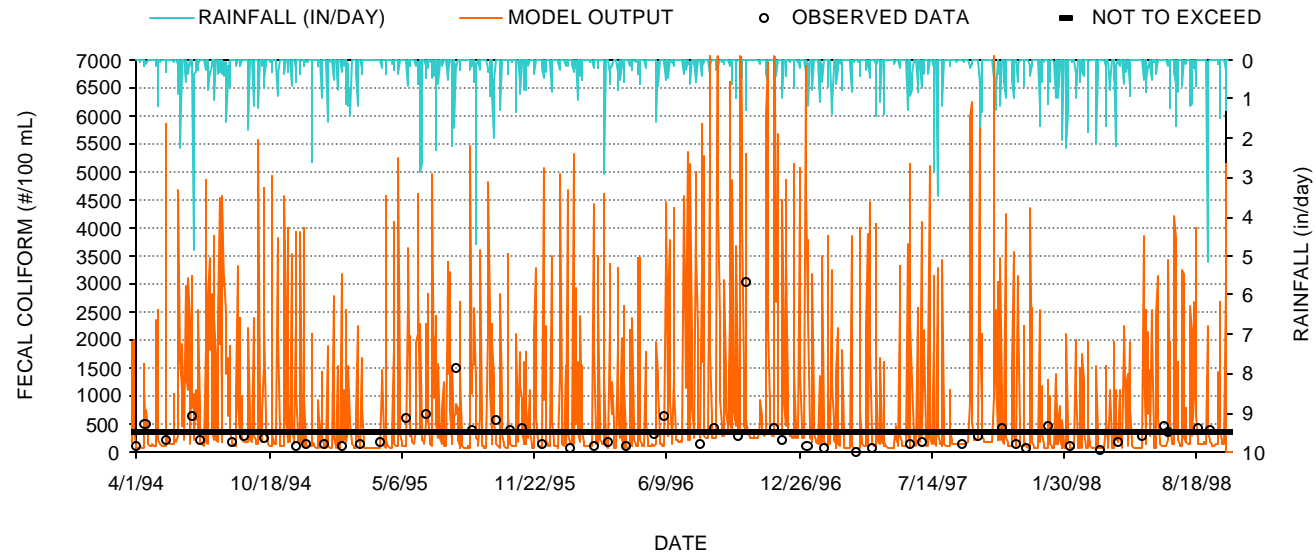
WQ Calibration S-260



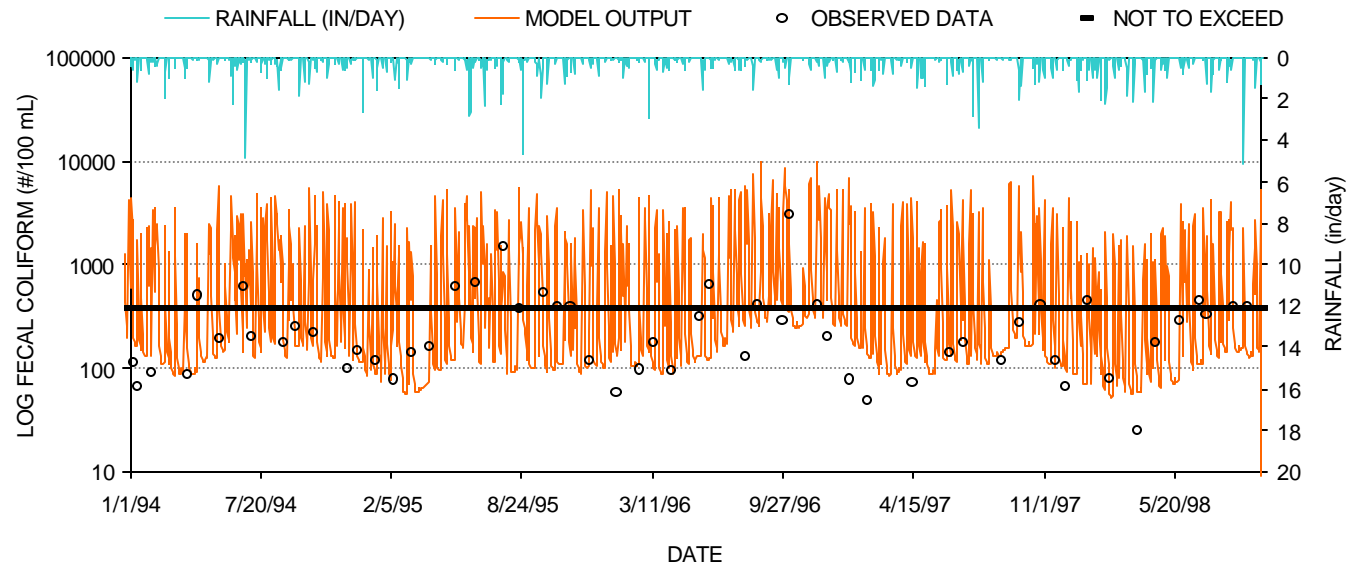
Log Plot WQ- S-260

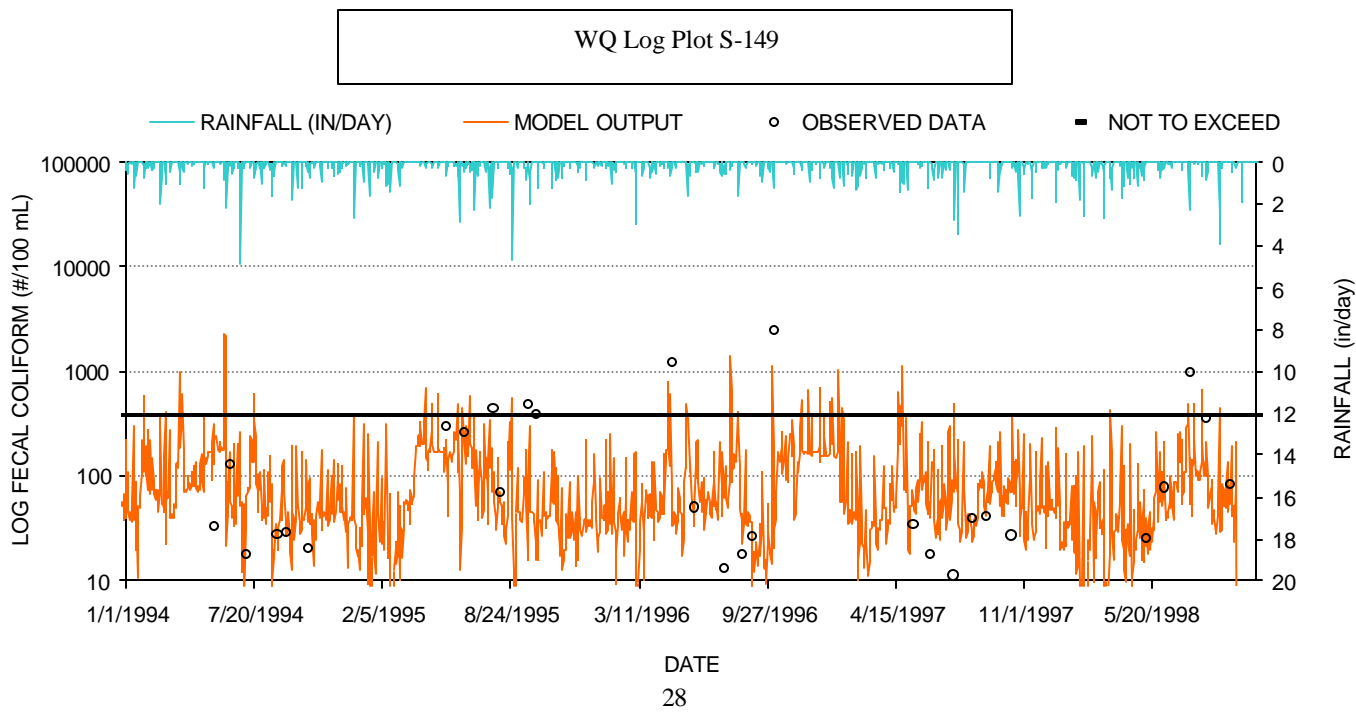
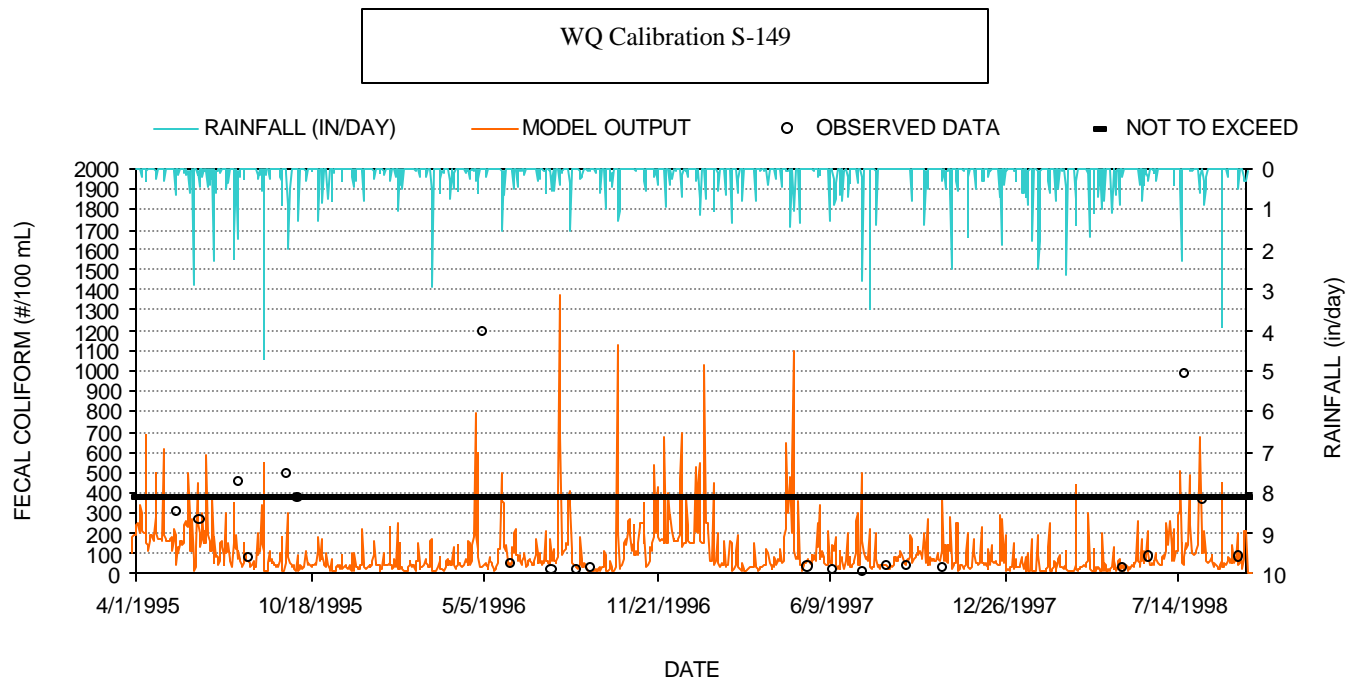


### WQ Calibration S-294



### Log Plot WQ S-294





<b>Animal Fecal Coliform Production Rates</b>						
Values from ASAE (1998) are used as default values when available.						
	<b>From ASAE, 1998</b>	<b>From NCSU, 1994</b>	<b>From Metcalf &amp; Eddy, 1991</b>	<b>From LIRPB, 1978</b>	<b>Best Professional Judgement</b>	<b>Mean</b>
<b>Animal</b>	<b>Fecal Coliform Bacteria (cfu/animal/day)</b>					
Cow	--	--	5.40E+09	3.75E+09	--	4.57E+09
Dairy cow	1.01E+11	1.04E+11	--	--	--	1.03E+11
Beef cow	1.04E+11	1.06E+11	--	--	--	1.05E+11
Hog	1.08E+10	1.24E+10	8.90E+09	8.91E+09	--	1.02E+10
Sheep	1.20E+10	1.22E+10	1.80E+10	--	--	1.41E+10
Horse	4.20E+08	4.18E+08	--	--	--	4.19E+08
Chicken	--	--	2.40E+08	2.37E+08	--	2.38E+08
Chicken (Layer)	1.36E+08	1.38E+08	--	--	--	1.37E+08
Turkey	9.30E+07	8.93E+07	1.30E+08	--	--	1.04E+08
Duck	2.43E+09	2.43E+09	1.10E+10	1.10E+10	--	6.71E+09
Goose	--	--	--	4.90E+10	--	4.90E+10
Deer	--	--	--	--	5.00E+08	5.00E+08

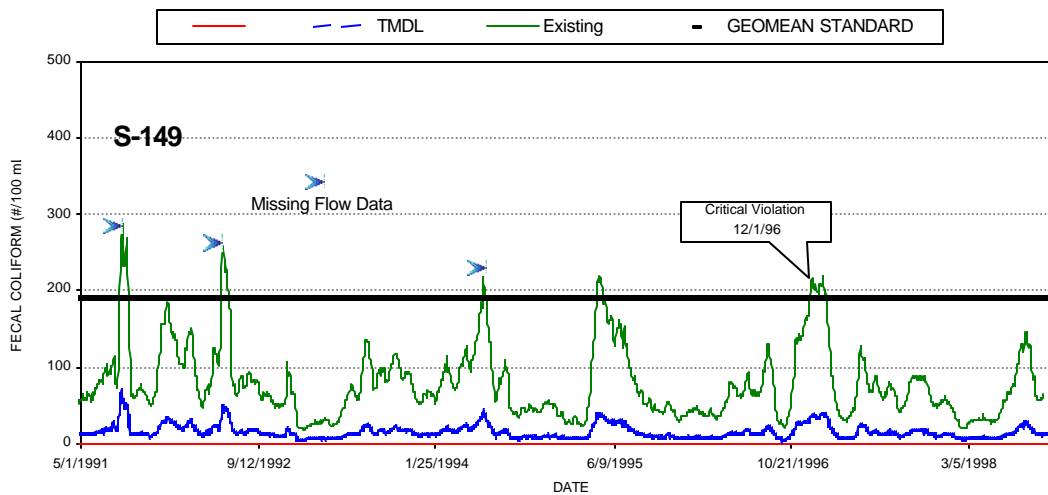
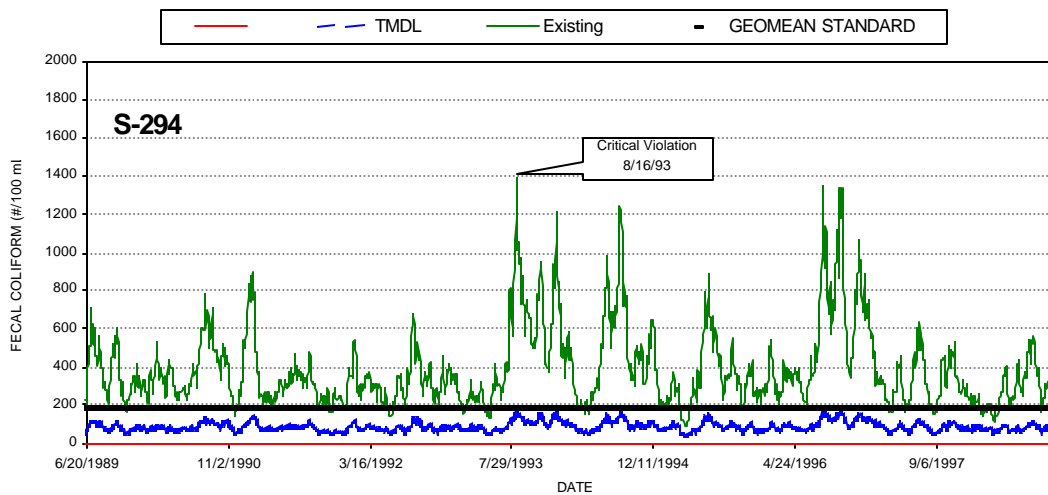
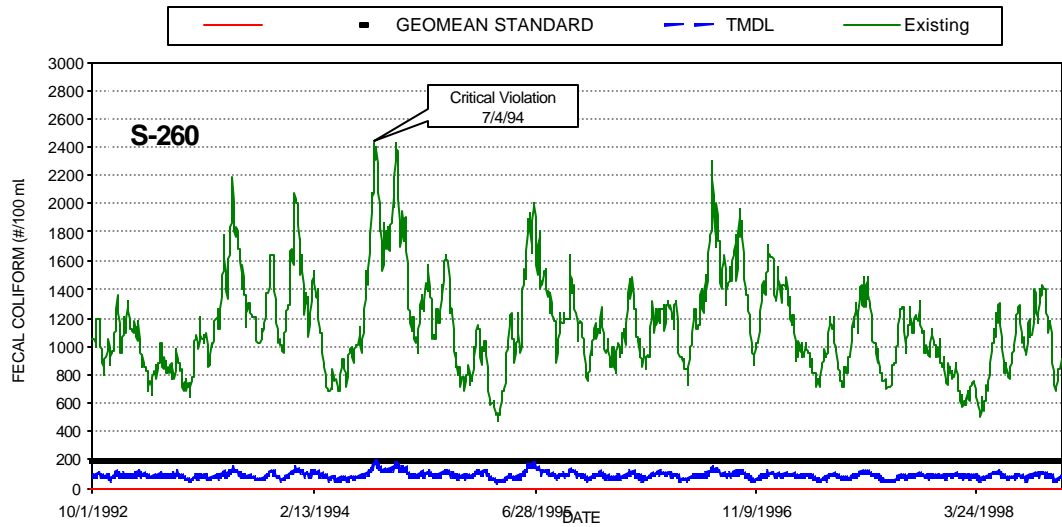
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**Modeled TMDL Conformance With 400cfu/100ml**

<b>S-294</b>	<b>12 Mile</b>			<i>Cfu/100ml</i>	<i># Samples</i>	<i>% Below</i>
<b>% &gt; 400</b>	<b>4.72895</b>			0	0	.00%
	<b>% Expected</b>			100	1087	62.69%
	<b>Exceedances</b>			200	313	80.74%
				300	177	90.95%
				<b>400</b>	<b>75</b>	<b>95.27%</b>
				500	51	98.21%
				600	22	99.48%
				700	4	99.71%
				800	2	99.83%
				900	1	99.88%
				1000	2	100.00%

<b>S-149</b>	<b>L. Saluda</b>			<i>Cfu/100ml</i>	<i># Samples</i>	<i>% Below</i>
<b>% &gt; 400</b>	<b>0.1734</b>			0	0	.00%
	<b>% Expected</b>			50	1638	94.46%
	<b>Exceedances</b>			100	49	97.29%
				150	24	98.67%
				200	12	99.37%
				250	4	99.60%
				300	2	99.71%
				350	1	99.77%
				<b>400</b>	<b>1</b>	<b>99.83%</b>
				450	3	100.00%
				500	0	100.00%

<b>S-260</b>	<b>Kinley</b>			<i>Cfu/100ml</i>	<i># Samples</i>	<i>% Below</i>
<b>% &gt; 400</b>	<b>6.805075</b>			0	0	.00%
	<b>% Expected</b>			100	1134	65.40%
	<b>Exceedances</b>			200	230	78.66%
				300	150	87.31%
				<b>400</b>	<b>102</b>	<b>93.19%</b>
				500	64	96.89%
				600	32	98.73%
				700	14	99.54%
				800	7	99.94%
				900	1	100.00%
				1000	0	100.00%